Space Weather Technical Forecast

Issued on Sunday, 16 June 2024 at 00:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor geomagnetic storm early Day 1 (16 Jun). Isolated M-class flares (R1-R2 radio blackouts) Likely throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Activity remained Moderate with GOES16 recording an M1.3 peaking at 15/0627UTC from AR3712 in the southeast quadrant. This is the largest and most complex of seven sunspots on the current Earth-facing disc.

The nominally most complex and threatening groups all lie in the eastern solar hemisphere, and foremost amongst these is AR3712. This has at least one candidate for a Mt Wilson delta spot within it, and has undergone significant proliferation of its intermediate spots, with these developing penumbrae and continuing to increase in overall area. Also of note is AR3716 in the northeast, which has also developed intermediate spots to become a compact group from its previously 'open' designation. Other groups were less noteworthy in the period, and amongst them is a newly-developed region in the northwest, AR3717.

A CME was observed leaving the Sun as a result of a large filament lift-off in the SE at 14/2200 UTC. This has been analysed as missing below Earths' orbit. No other Earth directed CMEs were in evidence.

Solar Wind / Geomagnetic Activity: Solar winds, and other parameters as observed by ACE at L1, indicated a CME arrival at 15/1102 UTC, most likely the expected arrival of the forecast M1 flare CME from 12/2246 UTC. Solar winds rose from background levels to slightly elevated, peaking at 482 km/s but generally averaging around 420-450 km/s. Density was generally below average, bur rose to average for a time around the onset of the CME. The Interplanetary Magnetic Field (IMF), Bt, increased from weak to moderate levels after the CME arrival, with a maximum value of nearly 16nT. The north-south component, Bz, also increased to moderate levels after initially being weak, ranging between +13 and -14nT after the CME onset. Phi angle was mostly negative (towards the Sun), but did experience some positive (away from the Sun) intervals at times. Geomagnetic activity was Quiet at first (Kp1-2), before reaching Active (Kp4) levels for the 15/1200-1500 period. It then fell to Unsettled (Kp3) for the rest of the period.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES18 remained below the S1 threshold and is now very close to resting Background levels.

High energy electron flux (greater than 2MeV) observed by GOES16 was mainly at Normal Background levels, with the associated 24-hour fluence well below Active. Observed fluence at 16/0001UTC was 1.0e6 integrated pfu.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Further isolated M-class flares are Likely, with a Slight Chance of X-class flares. Any significant flares remain most likely from AR3712 and AR3716 considering their complexity and growth. No significant regions are expected to depart or rotate onto the visible disc during the period.

Solar Wind / Geomagnetic Activity: Ongoing effects of the recent CME arrival are likely at first, with solar winds expected to slowly wane from their current slightly elevated levels. Unsettled to G1/Minor geomagnetic storm intervals are possible through early Day 1 (16 Jun). A high speed stream from CH45/+ may connect to Earth during Days 2 and 3 (17-18 Jun) with uncertain enhancement, perhaps seeing winds increase to 400-500km/s.

Overall, Unsettled to G1/Minor storm intervals (Kp3-5) are possible initially on Day 1 (16 Jun) due to lingering CME effects. Geomagnetic activity should then subside for a time back to Quiet to Unsettled levels (Kp2-3), ahead of a possible return to Active (Kp4) into the UTC working week on arrival of any fast wind from CH45/+.

Energetic Particles / Solar Radiation: High energy proton flux is now very close to resting Background levels. The chances of new enhancements are low given the more complex spots are situated in the less well-connecting eastern solar hemisphere for some days yet.

High energy electron flux is forecast to persist at predominantly Normal Background levels, and the associated 24-hour fluence is expected to remain below the Active threshold.

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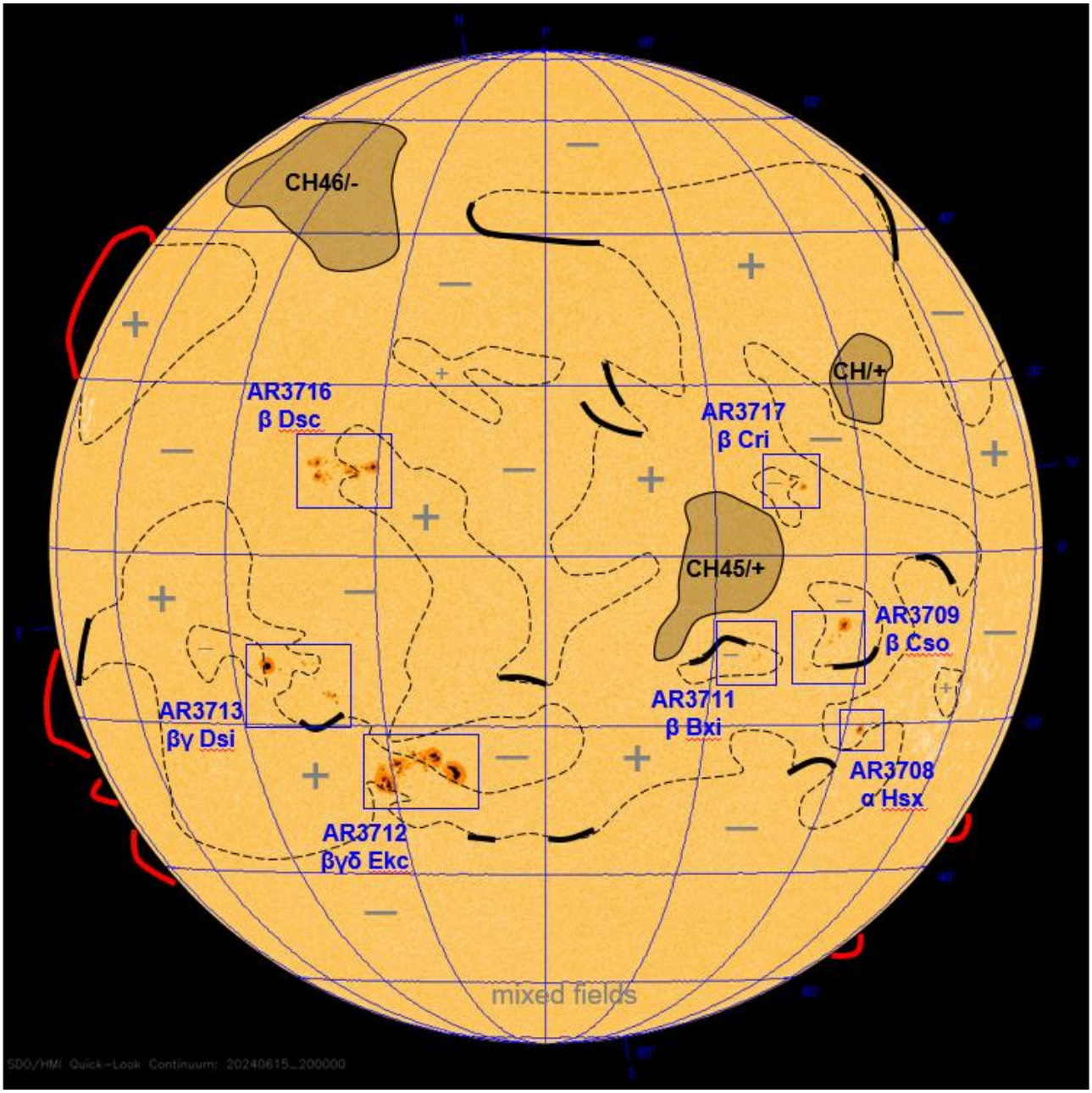
Figure 1. Solar Analysis Valid 15/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

No new CMEs feature in the forecast.

A CME arrival was observed, most likely from the M1 flare emitted at 12/2246 UTC. This was detected at the BGS Hartland magnetometer at 15/1155 UTC with a small magnetic impulse of 12nT along with a 26nT change in the four minutes from 15/1157 UTC. Solar winds rose to slightly elevated levels, as did the associated magnetic field. An Active interval (Kp4) was observed, and their remains a chance for Active to G1/Minor storm intervals to linger through the early hours of Day 1 (16 Jun) before waning.

One source of fast wind then rounds out the four-day forecast: CH45/+, which may connect with Earth on Days 2 and 3 (17-18 June). This feature is not recurrent and is therefore something of an unknown quantity, however due to our proximity to the solstice and CH45's limited visual (AIA211) size, solar wind speeds of 400-500 km/s are considered most likely. As a result, Unsettled or possibly Active (Kp3-4) geomagnetic intervals are possible. A faint unnumbered higher-latitude coronal hole feature that leads this hole by 20 degrees is not felt likely to feature in the forecast.

All considered, Unsettled to G1/Minor storm intervals (Kp3-5) are possible initially on Day 1 (16 Jun) due to lingering CME effects. Geomagnetic activity should then subside for a time back to Quiet to Unsettled levels (Kp2-3), ahead of a possible return to Active (Kp4) into the UTC working week on arrival of any fast wind from CH45/+.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	30	5	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

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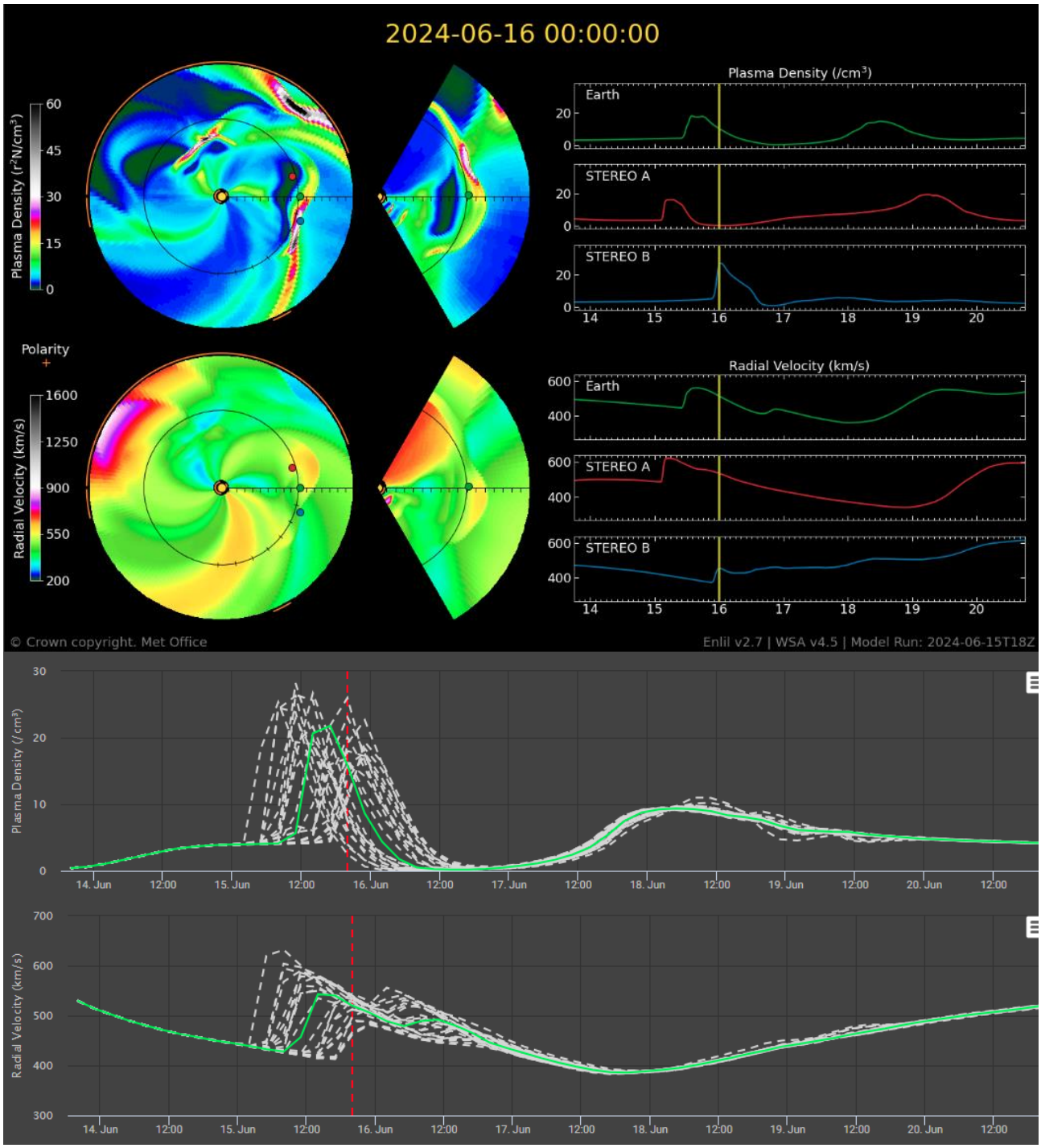
Figure 2: MOSWOC Enlil and ensemble models, showing waning effects of recent CME arrival as well as possible onset of CH45/+ (note: Enlil probably a touch late in coronal hole onset)



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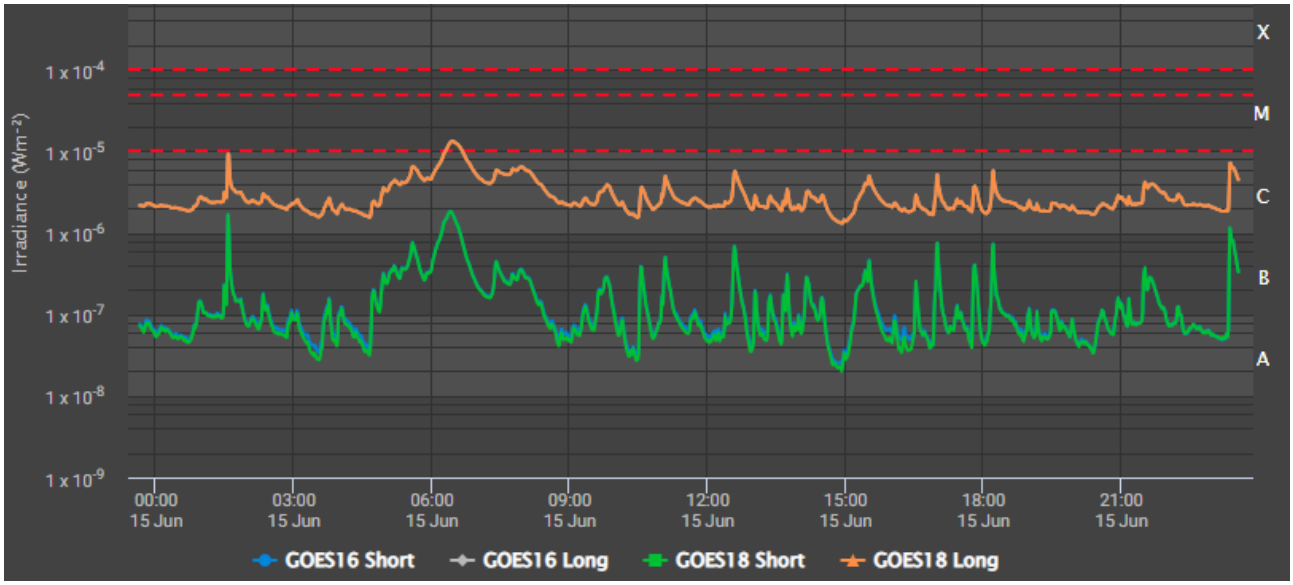
Radio Blackouts - X-Ray Flares:
The chances of significant flares are mainly due to both AR3712 and AR3716, with these two regions undergoing significant growth phases. Both of these sunspot groups now present as having 'compact' Zurich classifications, while AR3712 retains at least one Mt Wilson delta spot. AR3713 also showed some growth of intermediate spots. All flare activity in the past 24 hours for C-class and above has emanated from one of these three regions, particularly AR3712.

In terms of the forecast, no significant sunspot regions either arrive or depart in the period, and the risk is therefore held constant for now, but with possible minor variation likely tied to the evolution of these groups.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	60	60	60	60
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3: GOES-16 & -18 X-ray flux



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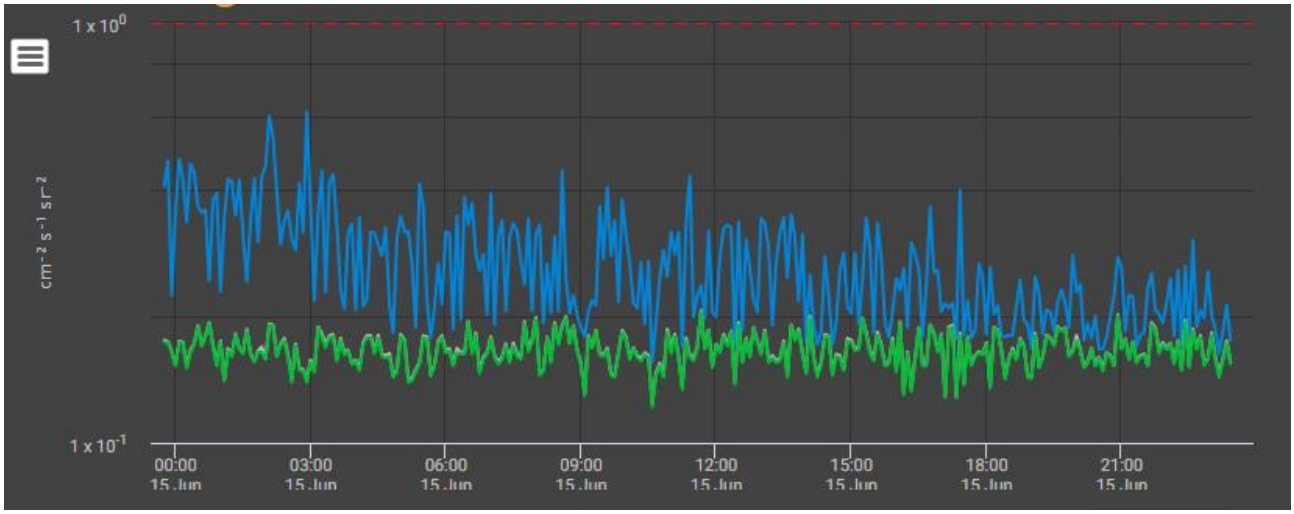
Solar Radiation Storms - (High Energy Protons):
High energy proton flux has almost reverted to resting Background levels. In terms of the future risk, Ex-AR3697 continues to rotate further across the far side and the most significant regions on the visible disc are currently in the eastern solar hemisphere. The daily risk of surpassing S1 is therefore very low but shows a slight increase towards the end of the period as AR3612 moves into a more centrally-located position on the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	5	5	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-18 Proton flux



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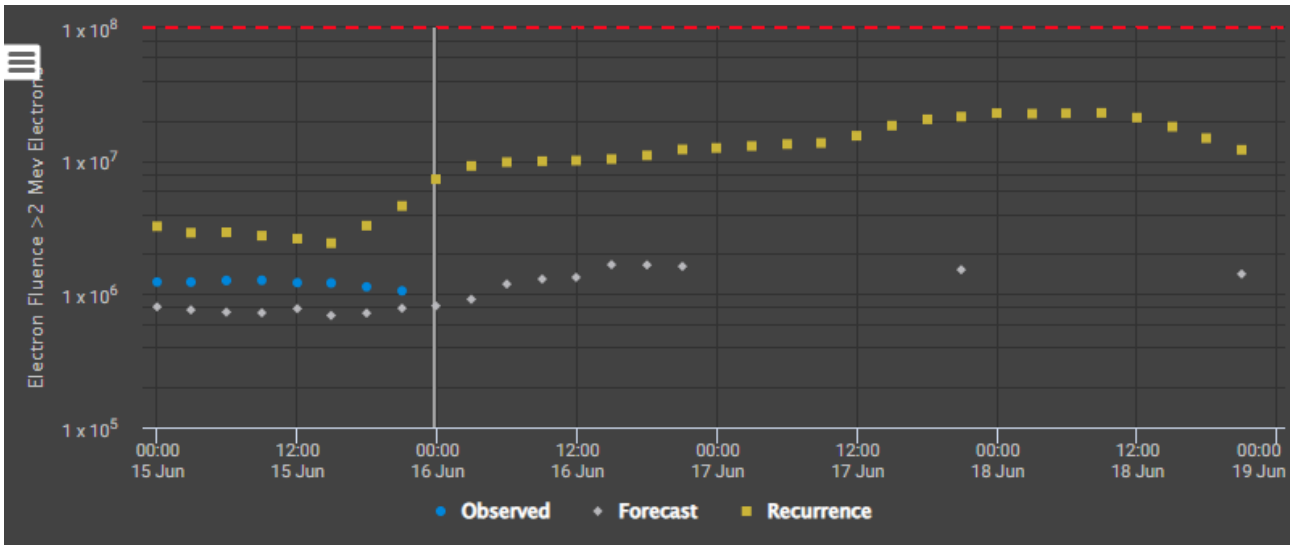
High Energy Electrons Event (≥ 2MeV):
The high energy electron flux is expected to persist at mainly Normal Background levels for much of this period, with the recent CME arrival likely only providing limited enhancement, although some diurnal Moderate flux values are likely. No other significant sources of enhancement are expected.

The associated 24-hour fluence is expected to remain well below the Active threshold (1e8 integrated pfu). The recent CME arrival should lessen the utility of MOSWOC REFM, however its current trend is considered to provide reasonably good guidance in the interim. The only other potential driver of increased counts at GEO is perhaps CH45/+, however any eventual fluence increase will come late in this forecast period - if at all.

GEO Electron Environment Probability (Exceedance)	Level ($cm^{-2}\,sr^{-1}\,day^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	10
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM model



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